Simultaneous Elemental and Microdiffraction Analysis of Ancient Greek Pigments from Chersonesos

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Introduction: The simultaneous XRD/XRF capabilities of the X26 Beamline have made possible the investigation of multiparticulate pigment traces from the ancient painted grave stelai of Chersonesos, an ancient Greek trading colony on the Black Sea in present-day Ukraine. Beyond a basic identification of the painting materials from what could arguably be considered the genesis of Western painting traditions, this information is expected to yield an improved understanding of the unique environmental conditions leading to rare cases of painting survival and to a "corrected" historical record through the identification of pigments whose presence can only be inferred from their alteration products.

Methods and Materials: Pigment samples, typically about 80 microns in size, were positioned in the beam after mounting on glass filament supports using mineral oil. Diffraction patterns were collected at a wavelength of .7424 Ångstroms using the Bruker CCD area detector to cover an angle of 10.7° to 35.6° 2Θ. Simultaneous energy dispersive X-ray spectra were collected. The magnified imaging system and sample translation stage allowed multiple patterns and spectra to be collected from samples with visible heterogeneities.

Results: The high degree of localization afforded by the 9 micron beam allows the collection of diffraction patterns for phase identification from pigment constituents that, though important, do not form a large enough proportion to be readily identifiable from the multiphase pattern of the mixture as a whole. Distinctly different diffraction patterns were obtained from sub regions of many of the samples. Even so, the patterns typically contain multiple phases. Alteration products derived from the original pigments and authigenic minerals introduced from the burial environment complicate the interpretation of the ancient remains but add new dimensions to their usefulness as well. The ability to collect discreet patterns from visually distinct areas of the sample has greatly facilitated the interpretation of diffraction data containing many phases. An improved understanding of the condition of these rare examples, and the circumstances of their survival, will yield benefits for their future conservation treatment and protection.

Conclusions: Synchrotron X-ray microdiffraction greatly facilitates the non-destructive investigation of very small multiparticulate samples by providing linked elemental and diffraction data sets from sub regions of the sample volume. This information will yield benefits in the investigation of ancient painting techniques and the conservation of surviving examples.

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Figure 1. Relief-carved grave stele with pigments, left; the "Doctor's Stele" showing the deceased physician, an immigrant to Chersonesos, treating a patient during his former practice, right.

Figure 2. Ancient Egyptian blue (cuproriviate) composite grain with quartz, between crossed polars, left; Birefringent alteration rind on conichalcite particle, crossed polars, right